World Applied Sciences Journal 28 (4): 578-582, 2013
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2013.28.04.1785

A Review of Cluster Heads Election in WSN

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Abstract: In recent years there has been a growing interest in Wireless Sensor Networks (WSN). Recent advancements in the field of sensing, computing and communications have attracted research efforts and huge investments from various quarters in the field of WSN. Also sensing networks will reveal previously unobserved phenomena. Network's lifetime depends on energy efficiency and load balancing of wireless sensor network. The main aim of clustering is to provide the scalability and reduce energy consumption. Cluster head consume more energy as compare to non cluster head nodes. Proper selection of cluster head increases the network lifetime and energy efficiency. This paper provides an overview of clustering, cluster head election mechanisms and LEACH protocol.

Key words: Wireless Sensor Networks · Clustering · Cluster head · LEACH

INTRODUCTION

Information gathering is a fast growing and challenging field in today's world of computing and networking. Sensors provide a cheap and easy solution to these applications in several areas. Sensors are tiny devices that are capable of gathering and capturing the physical information.

The use of wireless sensor networks has grown rapidly in the last decade, observing the crucial need for scalable and energy efficient routing and aggregation protocols in corresponding large-scale environments. In most wireless sensor network applications nowadays the entire network must have the ability to operate unattended in harsh environments in which pure human access and monitoring cannot be easily scheduled or efficiently managed or it's even not feasible [1].

One of the advantages of wireless sensors networks is the ability to operate unattended in harsh environments where contemporary human in the loop monitoring schemes are risky, not efficient and mostly time infeasible [2] [3].

A typical WSN consists of a number of sensor nodes that collaborate with each other to accomplish a common task like environment monitoring, target tracking, etc) and report the collected data through wireless interface to a base station or sink node. Sensor nodes have very limited battery power and they are randomly deployed it is impossible to recharge the dead battery. So the battery power in WSN is considered as scarce resource and should be efficiently used. Sensor node consumes battery in sensing data, processing data, transmitting data. Sensor nodes have very limited constraints in terms of energy, computing, storage and processing. Sensors are deployed in an ad-hoc manner in the area of interest to monitor events and gather data about the environment. Networking of these unattended sensors is expected to have significant impact on the efficiency of many applications. Sensors in such systems are typically disposable and expected to last until their energy drains. Therefore, energy is a very scarce resource for such sensor systems and has to be managed wisely in order to extend the life of the sensors for the duration of a particular mission. The remaining sections are organized as follows. Section II presents the survey the clustering techniques in wireless sensor network.

Section III presents the overview of energy efficient routing protocols. Section IV provides conclusion and future work.

WSN Clustering: Arranging sensor nodes into clusters has been widely adopted by the research community to achieve the scalability goal and high energy efficiency to prolong network lifetime in large scale WSN environments. Clustering techniques are used in hierarchical routing. A network becomes more manageable

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by partitioning it into clusters. Clustering is a method that aggregates the nodes into groups [4]. These groups are known as clusters. Clustering helps to improve routing at the network layer by reducing the size of the routing tables and it also decreases transmission overhead [5, 6]. Clustering aggregates topology information the number of nodes of a cluster is smaller than the number of nodes of the whole network. So, each node only needs to store a fraction of the entire network routing information [7]. The main elements of clustering are cluster head, cluster member and sink. Clustering consist of two main phases. One is cluster head selection and other one in cluster formation. Cluster head is act as a controller of cluster and its main function is to collect the information from nodes inside the cluster. In cluster formation phase the nodes joins the cluster head that falls in the transmission range of cluster head. The nodes inside the cluster are called cluster members. These nodes transmit the sensed data to CH. After aggregate and compress the received data from all the nodes CH transmit the data to BS. The node that lies in the transmission range of both the cluster heads is called Gateway node. Only gateways and cluster heads participate in the propagation of routing control/update messages [8].Clustering techniques can be divided into centralized, distributed and hybrid categories based on cluster head selection.

LEACH [21] protocol is the first distributed cluster based routing protocol for energy efficiency. It consists of two phase. In setup phase cluster head selection and cluster formulation are formed. While in steady phase routing is formed. Each node generate random number between 0 and 1 and if this number is less the probability threshold then the node will be elected as a cluster head for current round.

$$T(n) = \frac{P}{1 - P * (r * mod \frac{1}{p})} \quad (1)$$

where P is the desire percentage of cluster heads and r is the current round. But in LEACH there is possibility to elect a sensor node as a cluster head that has low residual energy and it may die sooner, as a result network's lifetime gets down and minimized. Table 1 shows the simulation parameters for LEACH protocol.

Based on the Table 1 the selected cluster heads for LEACH protocol are shown in Figure 1.

LEACH-C [22] is an example of centralized approach but it is not good for large scale WSN.

Each node has to send its location and energy information to base station. That's why it is called centralized approach because decision of cluster head selection is made by base station after receiving node's information. According to its author's 30% lifetime of network is improved. The new three metrics has proposed first Node Dies (FND), Half of the Nodes Alive (HNA) and Last Node Dies (LND). But overheads are high on base station due to centralized approach.

Distributed approach is good in terms of load balancing.CH schedules activities in the cluster so that nodes switch to the sleep mode and reduce the rate of energy consumption.

Sensors can be engaged in a round-robin fashion and the time for their sending and receiving can be determined so that the sensors reties are avoided, redundancy in coverage can be limited and medium access collision is prevented [9, 10, 11, 12].

Table 1: Simulation Parameters

Parameters	Values
Number of nodes	10 & 50
Network size	100m × 100m
BS location	(50, 175)
Radio speed	1Mbps
Data size	25 bytes
Initial node power	1J
Numbers of CH	5
Simulation time	100sec

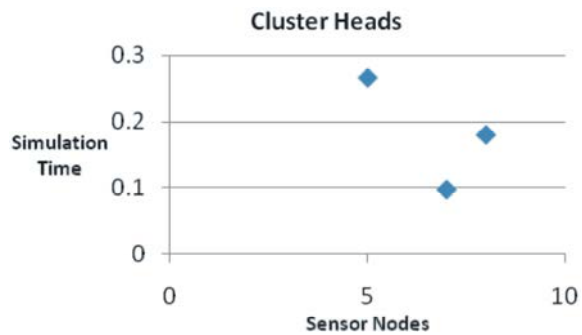

Fig. 1: LEACH Cluster Heads Selection (10 Nodes)

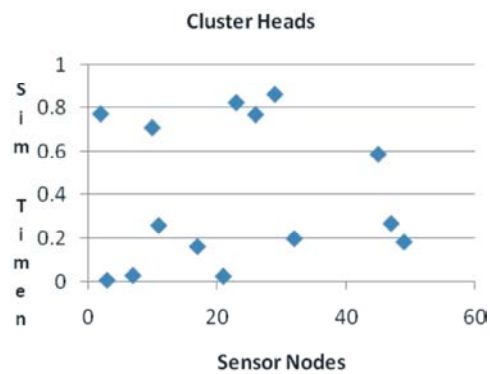

Fig. 2: LEACH Cluster Heads Selection (50 Nodes)

Clustering Attributes: WSN nodes are divided into groups called clusters to create a temporary infrastructure for the sensor nodes. Each cluster is supervised by a head node called Cluster Head (CH). Purpose of CH is to maintain the list of affiliated nodes called member nodes and communicate with other cluster Heads to send the data towards sink node [23].

Cluster Properties: There are some characteristics for cluster formation.

Cluster Size: It is better that cluster should be small sized because it minimizes transmission distance and load of cluster head

Cluster Count: It means how many clusters are formed in a single round. Large number of clusters leads to small size cluster distribution that is better in term of energy consumption.

Cluster Density: Cluster density is defined as proportion of the number of cluster member in the cluster and cluster area. It is a big issue to minimize the energy consumption of cluster heads in dense clusters.

Message Count: Large number of message transmission lead to large amount of energy consumption in the election of cluster head. Several non-probabilistic algorithms require the more message transmission for cluster head selection. It usually occurs in multi-hop communication.

Stability: The network topology will be said as adaptive if clusters members are not fixed.

Intra-Cluster Communication: Cluster members communicate to each other within a same cluster by Intra-cluster mechanism. It can be single hop and multi hop.

Inter-Cluster Communication: When cluster heads of different clusters are communicate to each other then it is called Inter-cluster mechanism.

Clustering Objectives: Several objectives have been pursued for forming clusters. Some of them are load balancing, network's lifetime and fault tolerance. Mostly clustering protocols rotates the role of cluster head among sensor nodes to balance the energy consumption. By using clusters load balancing network's lifetime and energy efficiency can be prolong. Multi path routing protocols provide fault tolerance mechanism to reduce packets lose. But multi path routing protocols send multiple copies of same data that increases routing overheads.

Cluster Head Election: Cluster head is the local base station of the cluster. Non cluster head node sends sensed data to cluster head. To maximize the sensor network lifetime and energy efficiency cluster head selection is an important issue. Cluster head election can be divided into two main categories.

Probability Based: In probability based clustering algorithms each sensor node uses pre assigned probability to determine the cluster heads. LEACH is probability based protocol.

Non-Probability Based: In this type of algorithms some other parameters are used for the selection of cluster head i.e residual energy, initial energy, degree etc.

Clustering Methods: It may be centralized, distributed and hybrid.

Distributed clustering algorithms give balanced cluster structure and load balancing as compared to centralized approach.

Cluster Formulation: In this phase cluster head broadcasts the request packet with its ID in a network and the nodes that fall in its transmission range join it as cluster members.

Clustering Schemes: In this section different clustering schemes are address that how to elect the cluster head.

Lowest Identifier Clustering: In this scheme the node with the minimum ID is chosen as a cluster head and the neighbors of the cluster head will be having the higher ID than that of the cluster head [13]. The node that falls into the transmission range of two cluster head is act as gateway. The purpose of gateway node is to forward the packet from one cluster head to other cluster head. The overcome of lowest ID algorithm is that certain nodes are prone to power drainage due to serving as cluster heads for longer periods of time.

Highest Degree: Every node decides to become a cluster head or remain an ordinary node by comparing the connectivity value of its neighbors with its own value. If a node has the highest connectivity value in its neighborhood it will become a cluster head [10].

K-CONID: It is the combination of LIC and highest Degree approaches Connectivity and the lower ID are considered as the criterion for the selection of the cluster heads [14]. Clusters in the k-CONID approach are formed by a cluster head and all nodes that are at distance at most k-hops from the cluster head.

Max-Min D-Cluster: In most of the clustering techniques the selection of cluster head in such way that no node can be more than one hop away from its cluster head. The main drawback suggested by [15] such approaches are congestion.

Max-Min clusters are formed by nodes that can be at most d-hops away from the cluster head. In this approach d is defined as the maximum number of hops away from the nearest cluster head (d _ 1).

Weighted Clustering: It is a distributed approach and presented in [16]. Each node will determine its weight. In order to optimize energy consumption and load balancing a node is chosen to be a cluster head according to the number of nodes it can handle, mobility, transmission power and battery power. The node will be elected as a cluster head which has greater weight value.

$$w_V = w1\Delta_v + w2\ D_v + w3M_v + w4P_v \quad (2)$$

w_1, w_2, w_3, w_4 are the weighting factors and the total of these weighting factor must be equal to 1.

Multi Hop Approach: Multi hop Clustering [17] technique provides small number of multi-hop clusters with large size, so as to support large scale networks. This approach increases the lifetime of the network and reduces the overhead of cluster maintenance.

Improved WCA (iWCA): It is the improved version of the WCA and called as improved weighted clustering algorithm. It proposed in [18] to keeping a node with weak battery power from being elected as CHs to minimizing the number of clusters and minimizing the overhead for the clustering formation and maintenance.

WCA with Mobility Prediction: A modified version of the Weighted Clustering Algorithm (WCA) [19] is proposed for the cluster formation and mobility prediction for cluster maintenance.

It uses linear auto regression for predicting mobility to minimize the overhead in communication and cluster formation.

New Weighted Adaptive Clustering Approach: The aim of proposed technique [10] is to reduce the transmission overhead, total required time and increasing the stability of the formed cluster by EWCA. WACA creates multi-level hierarchical clusters. It works on local information only and supports well structure multi hop clusters by introducing cluster sub heads.

CONCLUSION

Clustering based techniques plays an important role for network scalability, energy efficiency and reducing overheads. Cluster head selection is major challenge to prolong energy efficiency and network's lifetime. Researchers have proposed different mechanisms to select cluster head but still it open research problem for prolonging network's lifetime. This paper focused on clustering importance and cluster head selection mechanisms.

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